Characterisation of the trumpeter (Latris lineata) fishery in TRU 3 and TRU 4, and size at maturity

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EXECUTIVE SUMMARY

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A characterisation of the commercial and recreational fisheries was carried out for TRU 3 and TRU 4, as well as a sampling programme to estimate size at maturity and maximum age.

TRU 4 characterisation

TRU 4 is the single most-important trumpeter QMA, accounting for over 59% of total reported landings over the 1989–90 to 2006–07 fishing years since trumpeter was included in the Quota Management System (QMS). TRU 4 catches show cyclical peaks and troughs—catches increased to 69 t in 1995–96 followed by an 11-fold decline in the early 2000s, then peaking at 70 t in 2004–05. Catches have exceeded the TACC (59 t) in the four year period 2004–05 to 2007–08, averaging 66 t. The extent to which these large scale fluctuations reflect changes in trumpeter abundance or are an artefact of effort in other fisheries is unknown.

The fishery is small scale with annual landings ranging from 5 to 70 t. There is little evidence for seasonality in the TRU 4 landings. Catches were recorded mainly from near the Chatham Islands (statistical areas 049–051), and also over the Reserve Bank (statistical areas 401 and 407) on the Chatham Rise. Most of the TRU 4 catch has consistently been caught by bottom longline, with lesser catches by dahn line and trot line in the mid 1990s, and modest catches by bottom trawl in recent years. Target species are mainly bluenose (BNS), hapuku (HAP), hakuku/bass (HPB), and ling (LIN), which are typically targeted using lining methods. Targeting for ling has declined over recent years, and since 2002–03 significant catches have been reported by vessels recording trumpeter as the target, using bottom longline. The bulk of landings for bottom longlining and non trawling methods were from vessels completing Catch Effort Landing Returns (CELR). Bottom trawl landings were mostly from larger vessels (over 28 m) using Trawl Catch Effort Processing Returns (TCEPR), indicating that much of the bottom trawl bycatch is from deeper water. Most of the vessels using bottom longline completed the longline specific Lining Catch Effort Return (LCER) from 2003–04 onward, while the remainder of vessels using this method continued to report on CELRs. Methods used, areas caught, and total landings are strongly associated with the target species and may explain the large fluctuations in annual landings.

TRU 3 characterisation

TRU 3 is the second most important QMA (after QMA 4), accounting for over 17% of total reported landings over the 1989–90 to 2006–07 fishing years since trumpeter was included in the QMS. TRU 3 catches also show cyclical peaks and troughs—catches peaked in 1996–97 at 35 t followed by a 7-fold decline, and in the last few years have been increasing again with a catch of 22 t in 2007–08. The extent to which these large scale fluctuations reflect changes in trumpeter abundance or are an artefact of effort in other fisheries is unknown.

The fishery is small scale with annual landings ranging from 1 to 35 t. There is little evidence for seasonality in the TRU 3 landings, although landings in July and August were comparatively low. Catches were recorded from all TRU 3 coastal statistical areas (018, 020, 022, 024, 026) and also offshore from Kaikoura (019) and over the Mernoo Bank (021). Largest catches were from 018, 020, and 024, and more recently 021. Most of the TRU 3 catch has consistently been caught by either set net or bottom longline, although catches by set net declined sharply after 1998. There were also lesser catches by bottom trawl. Trumpeter is a bycatch of at least eight target species and more recently the highest landings have been associated with targeting hapuku/bass (HPB) and school shark (SCH). There were also modest landings with TRU recorded as the target. The bulk of landings from bottom trawl were from vessels completing CELR forms with some reporting from larger vessels (over 28 m) using TCEPR forms in the early 1990s. Some vessels using bottom longline completed LCERs in 2004–05 and 2006–07, while the remainder of vessels using this method continued to report on CELRs. Similarly, after

the introduction of the Net Catch Effort Landing Return (NCELR) in 2006–07, it was used by all vessels landing trumpeter by set net in TRU 3.

Methods used, areas caught, and total landings are strongly associated with the target species and may explain the large fluctuations in annual landings.

Recreational fishery

The recreational harvest estimate for TRU 3 in 1999–2000 was converted to weight using estimated mean fish weight (952 g) and was 39 t. This is four times greater than the average TRU 3 commercial catch over the last 10 years (10.6 t up to 2007–08). TRU 3 recreational fishing survey length frequency data indicate that most fish caught are small (less than 45 cm). There are no recreational fishing survey data for TRU 4.

Size at maturity

We sampled 81 trumpeter caught by commercial set nets from Stewart Island and Kaikoura, and a recreational fisher from Karitane. The recorded fork length ranged between 23 and 74 cm with a sex ratio of close to 1:1. Overall mean length was 42.0 cm and median 38.0 cm. There was very little difference between male and female distributions and mean lengths were similar (42.2 and 41.8 cm respectively). Fish caught from shallow inshore waters (Stewart Island and Karitane) were small (less than 45 cm), whereas those caught offshore in deeper water near Kaikoura were large (60 cm and over). There were no fish in the size range 45–59 cm.

The trumpeter length-weight coefficients from the sampled fish (both sexes combined) were a = 0.011612 and b = 3.09, where $W = aL^b$, W = weight (g), and L = length (cm). (N = 81; range 23–74 cm, 242– 7152 g; $R^2 = 0.99$).

From our sampled fish, all gonads from inshore fish less than 45 cm were immature (never spawned) and all fish from offshore over 60 cm were mature. Missing were the intermediate sizes (45 to 60 cm) within which they mature. We estimate that 50% maturity is between 45 and 50 cm. Results of the sampling (and the recreational survey length data) are consistent with what is known of the life history of Australian conspecific trumpeter which moves offshore to spawn at about 45 cm fork length.

Otoliths were collected but no fish were large enough to warrant otolith processing to estimate maximum age.

1. INTRODUCTION

1.1 Distribution

Trumpeter (*Latris lineata*) is a latrid fish with a southern hemisphere distribution in cool temperate waters. It occurs in New Zealand, Australia, the subantarctic islands of the southern Indian and Atlantic oceans, the Foundation Seamount in the central South Pacific, and possibly off Chile (Roberts 2003, Tracey & Lyle 2005). Within the New Zealand Exclusive Economic Zone (EEZ) trumpeter occur from the Three Kings Islands around all of mainland New Zealand to the Auckland Islands, but are rare north of East Cape and Cape Egmont (Kingsford et al. 1989, Francis 1996, 2001). The greatest concentrations apparently occur on the Chatham Rise and around the southern South Island and Stewart Island.

Trumpeter have an extended larval and postlarval stage lasting up to 9 months in surface waters (Tracey & Lyle 2005), resulting in extensive drift of young fish among geographic regions. Juveniles are largely sedentary, but some adults are highly migratory, with tagged fish travelling 650 km from Tasmania to southern New South Wales, and 5800 km from Tasmania to St Paul Island in the southern Indian Ocean (Lyle & Murphy 2002). Such large scale movements are consistent with a single circum-global genetic stock in the southern hemisphere, although regional variation in otolith shape among populations from Tasmania and St Paul and Amsterdam Islands (Tracey et al. 2006) suggests that migration and interbreeding may be limited.

Trumpeter occur mainly over rocky reefs ranging from shallow inshore waters to deep reefs on the central continental shelf. In New Zealand, they apparently range from a depth of a few metres down to about 200 m. In Australia some reports indicate they may go as deep as 300 m (reviewed by Paul 1999) Fish inhabiting inshore reefs tend to be small and immature, whereas fish from deep reefs tend to be much larger and mature. Trumpeter initially settle on inshore reefs at the end of their long postlarval period, where they remain for several years, before migrating into deeper areas as they reach maturity (Tracey & Lyle 2005).

1.2 Biology

Some biological traits differ between New Zealand and Tasmanian populations. Notably, trumpeter are said to spawn in winter (July) in New Zealand (Graham 1939), compared to late winter to spring in Australia (peaking around September in Tasmania) (Ruwald et al. 1991, Furlani & Last 1993, Morehead 1998, Morehead et al. 1998, Furlani & Ruwald 1999). However, the New Zealand information is based on limited sampling and it is uncertain whether the apparent regional difference is real.

Trumpeter grow to about 110–120 cm fork length (FL) and 25–27 kg weight in New Zealand and Australia (Gomon et al. 1994, Paul 1999, Francis 2001). Nothing is known about growth, longevity, or maturity in New Zealand waters. However, because of their importance for aquaculture in Australia, a comprehensive study has recently been completed on their age and growth in Tasmania (Tracey & Lyle 2005, Tracey et al. 2006). Partial validation of age estimates involved comparison of otolith growth in known-age reared fish and wild fish (enabling validation of the time of formation of the first growth band), and tracking a strong wild cohort over seven years (ages 1+ to 7+). Although full validation was not achieved, the authors (Tracey & Lyle 2005, Tracey et al. 2006) considered their ages validated up to and beyond the size and age of habitat transition.

In Australia, trumpeter grow rapidly during the first 4–5 years, reaching about 45 cm FL before moving offshore to deeper water, after which there is a reduction in growth rate (Tracey & Lyle 2005, Tracey et al. 2006). Maximum age is about 43 years, although the largest fish in the samples was 95 cm FL, which is well below the reported maximum length of 120 cm. There are no clear differences between males and females, although small sample sizes of fish older than 10 years meant the power to detect differences was

low. Similarly, no differences were found in growth rates between fish from Tasmania and St Paul and Amsterdam Islands. Growth rates are seasonally variable, at least for the first few years, with maximum growth in late summer-autumn. It is thought that maturation coincides with the offshore movement to deep habitat.

In New Zealand, the only population information available for trumpeter comes from a six year survey (1994–99) in Paterson Inlet, Stewart Island (Chadderton & Davidson 2003) in which underwater visual counts were made, and comprehensive length-frequency distributions recorded from 1065 fish caught by rod at 12–15 sites. Their length-frequency data show two or three clear juvenile cohorts which progress through time (a strong cohort was also found in Tasmania by Tracey & Lyle (2005)). Chadderton & Davidson (2003) interpreted this as evidence of variable annual recruitment pulses. Their largest fish was 46.9 cm FL with few fish over 40 cm in most years. This is consistent with evidence from Australia of offshore migration at about 45 cm, though the migration may occur at a slightly smaller size in the New Zealand population.

1.3 Commercial fishery

Trumpeter were introduced to the Quota Management System (QMS) in 1998–99 with an overall TACC of 100 t (Ministry of Fisheries 2009), increasing to 144 t in October 2001; TACCs were increased in all QMAs at this time and no explanation is given for this in the trumpeter Plenary document (Ministry of Fisheries 2009). Further, the TACC increase occurred when catches were well below TACCs for all stocks. Landings have never reached the TACC in any QMA except TRU 4 in the four most recent years (2004–05 to 2007–08) where catch has averaged 66 t and the TACC is 59 t (Figure 1). QMAs are equivalent to Fishery Management Areas (FMAs) (Figure 2). Commercial landings of trumpeter are relatively small and most of the landings come from TRU 3 and TRU 4, and to a lesser extent TRU 2 and TRU 5. In the main trumpeter fisheries, landings since 1982–83 were highly variable ranging from 1 to 25 t (TRU 3) and from 4 to 70 t (TRU 4) (see Figure 1). There seems to be a cyclical pattern in the catches with strong peaks and troughs in both TRU 3 and TRU 4. Both fisheries exhibited large increases in landings in the early–mid 1990s followed by declines in the late 1990s–early 2000s. Both fisheries have shown increases in landings in recent years, particularly TRU 4. Trumpeter is almost exclusively a bycatch species and landings depend on the characteristics of other fisheries. For example, it is a bycatch of set netting for butterfish, rig, school shark, and hapuku, and of longlining for ling, bluenose, and hapuku (Mernoo and Chathams), with small amounts landed from trawl. The extent to which these large scale fluctuations reflect changes in trumpeter abundance or are an artefact of effort in other fisheries is unknown

1.4 Recreational fishery

Trumpeter are also taken by recreational fishers, and a number of national recreational fishery surveys have provided estimates of the recreational harvest numbers of fish throughout New Zealand including FMA 3, but not FMA 4. These surveys were carried out in 1996–97 (Bradford 1998), 1997–98 (James & Unwin 2000), and 1999–2000 (Boyd & Reilly 2005). No landed weight estimates are given for these surveys, but the recreational catch was significant and may be similar to the commercial catch in these areas.

The South Marine Recreational Fisheries Advisory Committee (Dunedin) has raised concern about the small size of trumpeter being taken, and requested that MFish look at increasing the Minimum Legal Size (MLS, currently 35 cm) to prevent what they perceive as poor practice. In Tasmania, a MLS of 45 cm has been implemented. However, trumpeter migrate to deeper waters on the edge of the shelf around this size and a MLS of 45 cm might deny recreational fishers access to the fishery from inshore areas in New Zealand. In Tasmania, recreational fishers now catch large trumpeter from deep reefs, and do not appear to have been greatly affected by the introduction of a MLS (Jeremy Lyle, Tasmania Aquaculture and Fisheries Institute, Hobart, pers. comm.).

1.5 This study

It is important to understand the biology, habitat requirements, and migrations of trumpeter in order to develop appropriate management measures. Information on growth, size, age at maturity, and longevity is necessary as a basis for informing such management measures. In addition, knowledge on the characteristics of trumpeter fisheries is required before implementing any change to regulations.

This project has two objectives (see below). For reporting purposes we present these objectives in reverse order, beginning with objective 2 (characterisation of the fishery in TRU 3 and TRU 4) before presenting objective 1 (age and length at maturity).

Overall objective

1. To summarise the knowledge of the biology of trumpeter (*Latris lineata*) and characterise the New Zealand trumpeter fishery.

Specific objectives

1. To determine the maximum age and length of maturity of trumpeter in New Zealand.

2. To characterise the commercial and non-commercial fisheries for trumpeter in New Zealand in QMAs 3 and 4.

2. METHODS

2.1 Commercial fishery characterisation (TRU 3 and TRU 4)

2.1.1 Data sources

Trumpeter landing data were extracted from the Ministry of Fisheries (MFish) catch-effort and landings database. The data include all trips where a non-null, non-zero, TRU landing was reported between 1 October 1989 and 30 September 2007, and include all fishing and landing events associated with these trips.

2.1.2 Grooming and restratification (roll-up method)

These datasets were groomed and restratified using Starr's "roll-up" data processing method (Starr 2007). The method firstly identifies a set of relevant or "candidate" fishing trips, and then landing event records associated with each trip are extracted for processing.

We applied Starr's (2007) effort restratification and landed catch allocation algorithm to the extracted characterisation dataset. The algorithm is designed to facilitate analysis of MFish catch-effort data collected using a range of form types. Its aim is to overcome the main limitation of the catch effort reporting system, which is that fishers are required to report only the top five species in their CELRs and TCEPRs, resulting in the frequent non-reporting of species that make up only a minor component of the catch, such as trumpeter. A further benefit is that it allows catch-effort and landings data collected using different form types that record data with different spatial and temporal resolutions, e.g. CELRs and TCEPRs, and Catch Landing Returns (CLRs), to be combined in the same analysis. Fishery specific catch-effort and landings forms with greater spatial and temporal resolution than the CELR were introduced in 2003–04 for lining methods for vessels over 28 m (Lining Catch Effort Return,

LCER), and 2006–07 for set netting vessels over 6 m (Net Catch Effort Landing Return, NCELR). The bulk of our extracted data come from forms that pre-date reporting by LCERs and the NCELRs.

The basic unit of data within the algorithm is the fishing trip. The major steps are as follows:

Step 1: The fishing effort and landings data are first groomed separately. Outlier values in each variable that fail a range check are corrected using median imputation. This involves replacing missing or outlier values with a median value that is calculated over some subset of the data. While this may lead to underestimates of the variance for a given variable, this uses the data to "fix itself" rather than merely dropping cases containing missing or outlier data, maximising the amount of data available for analysis while eliminating missing or implausible values.

Step 2: The fishing effort within each valid trip is then restratified by statistical area, method, and target species.

Step 3: The greenweight landings for each fishstock for each trip are then allocated to the effort strata. The greenweight landings are mapped to the effort strata using the relationship between the statistical area for each effort stratum and the statistical areas contained within each fishstock.

Step 4: The greenweight landings are then allocated to the effort strata using the total estimated catch in each effort stratum as a proportion of the total estimated catch for the trip. If estimated catches are not recorded for the trip, although a landing was recorded for the trip, then the total fishing effort in each effort stratum as a proportion of the total fishing effort for the trip is used to allocate the greenweight landings.

2.1.3 Descriptive analyses

The characterisation analyses were carried out using the groomed, restratified, and merged trumpeter datasets. We firstly explored the relationship of fishing year with the associated effort strata month, location (QMA), method, and target species using bubble plots for each QMA. We then examined the data for each QMA (TRU 3 and TRU 4) separately (i.e., fishing year by month, statistical area, method, and target species). Lastly, we plotted trumpeter catch against combinations of the variables fishing year, month, statistical area, method, target species, and form type, for each QMA.

Landed catch was compared with estimated catch to determine the degree to which trumpeter are landed from a trip but not recorded in the top five species.

2.2 Observer length data

The fisheries observer database was interrogated for trumpeter length data. There were few data and all trumpeter lengths were extracted regardless of QMA.

2.3 Recreational fishery characterisation (TRU 3 and TRU 4)

The *rec_data* database was interrogated for all records of length collected during recreational fishing surveys. The data were then restricted to length records from FMA 3 (TRU 3) and also recreational fishing zones adjacent to FMA 3. The length data were plotted separately for the two areas.

Recreational catch estimates from national recreational fishing surveys in 1996–97 (Bradford 1998), 1997–98 (James & Unwin 2000), and 1999–2000 (Boyd & Reilly 2005) were tabulated. These surveys

provided estimates of the numbers of fish taken, not total weight, so we used the length-weight data collected in this study (objective 1) to convert numbers of fish to weight based on the mean length of the recreational fish landed into TRU 3 (see above). This was done by multiplying the mean weight by the estimated number of fish.

2.4 Maximum age and length at maturity

Objective 2 was to determine size at maturity, and longevity through maximum age. Existing NIWA records of length and age of trumpeter are limited to individual fish caught occasionally during research trawl surveys, and were not considered for this study due to the paucity of data. We therefore developed and implemented a specific programme to obtain a representative sample of trumpeter spanning the full population size range from juveniles in inshore habitats to mature adults on offshore reefs. This had the added advantage of being able to gather maturity status data for all sampled fish using a single gonad staging protocol, with one person assigning maturity to all fish. It was anticipated that of these sampled fish there would be some very large individuals which would provide the otoliths from which to estimate maximum age.

2.4.1 Trumpeter sampling

When to sample and how many

Determining maturity status in bony fishes can be difficult outside the season when gonad development and spawning occur. The gonads of mature resting (post-spawning) fish may be indistinguishable from those of immature fish that are developing for the first time. It is therefore desirable to sample fish for maturity status around the spawning period. In New Zealand, this is thought to be in winter and possibly early spring so sampling effort was focused on August–December to improve our chances of collecting specimens that could be staged unambiguously, by macroscopic examination. Our aim was to obtain a sample of 200 trumpeter of a representative size range.

Sources of trumpeter

Five commercial fishing operators were contacted in mid 2008 and requested to provide trumpeter (purchased by NIWA under special permit) from set net (TRU 3) or longline (TRU 4) fishing operations over the purported spawning period in late winter/spring. Set net fishers were based at Stewart Island, Karitane, Moeraki, and Kaikoura, and trumpeter tended to be bycatch of targeting butterfish, rig, hapuku, ling or deepwater sharks. The longline operator was based in Lyttelton from where they steamed to the Chatham Islands and/or the Mernoo Bank to target bluenose, hapuku, or ling. A number of recreational fishers and charter boat operators from Dunedin to north Canterbury were also contacted, including the Tautuku Fishing Club (Dunedin) and the South Marine Recreational Fisheries Advisory Committee. All the above parties were contacted again, on multiple occasions, in 2009 in an attempt to acquire more samples. This was also complemented with an advertisement in the September 2009 issue of the Fishing Paper promoting the programme and requesting samples. Further, the senior author was interviewed on Radio Talkback ZB on 14th August 2009, during which a further request for trumpeter samples was made.

Fish sampling procedure

Trumpeter provided to this programme were landed green, and freighted to NIWA (Dunedin) for analysis, either on ice or frozen. We requested information from the fisher on location of capture, method, and target species.

For each fish we recorded fork length (down to the nearest centimetre) and green weight (±2 g). Gonads were staged and then excised and weighed (± 0.1 g). Gonads representative of all stages were photographed using a digital camera. Both sagittal otoliths were removed and stored in paper envelopes.

2.4.2 Ageing

Otoliths were removed from all sampled trumpeter and archived at NIWA, Greta Point in the otolith library and entered on the *age* database. We planned to age at least 10 of the largest trumpeter sampled to establish a first estimate of longevity in New Zealand. The largest trumpeter in our samples was 74 cm which is considerably less than known maximum size of 110 cm. Therefore, ageing was not carried out for any of the fish collected during this study.

We also interrogated the *age* database for trumpeter otoliths of large fish that may have been collected by observers or during research surveys. There were 17 pairs of otoliths from fish ranging from 41 to 81 cm FL. The largest fish was collected by observers in 2007 on the Chatham Rise. Again this was too small to offer an estimate of maximum age so no ageing was carried out on these otoliths.

The decision not to age any otoliths was made in consultation with the Ministry of Fisheries.

2.4.3 Gonad staging and maturity status

Trumpeter gonads were scored using the NIWA middle depths gonad staging definitions (Table 1). This 7-stage scale theoretically distinguishes between immature (stage 1) and mature stages (resting through to spent, stages 2–7), so is suitable for determining length at maturity. All gonads were scored by one staff member (MPB). As an additional measure of sexual maturity the gonadosomatic index (GSI) was calculated for each fish as the gonad weight expressed as a percentage of fish weight (i.e., gonad weight/fish green weight x 100).

Data were presented as GSI versus length, the average gonad weight for each gonad stage, and the proportion of mature fish at length.

3. RESULTS

3.1 Commercial fishery characterisation (TRU 3 and TRU 4)

3.1.1 Catch effort data quality

The relationship between landed (QMR and CLR) and estimated catch in TRU 4 is shown in Figure 3. The landed greenweight catch is virtually identical to the reported QMR catch, as expected. The estimated catch as a proportion of the CLR landed catch varies from 0.5 to about 1.0. This indicates that, for many landings, trumpeter as a bycatch species did not make the top five species by weight. This is more evident from a scatter plot of landed catch versus estimated catch and a density histogram plot of landed catch/estimated catch (Figure 4). A large number of zeros in the plots, indicates that many trips returned a landed greenweight record but no corresponding estimated catch. Figure 4 also shows that estimated catch is frequently, but not always, less than landed catch.

Similarly, for TRU 3 the landed greenweight catch is also virtually identical to the reported QMR catch (Figure 5). The estimated catch as a proportion of the CLR landed catch averages about 0.70., indicating that for many landings trumpeter, has not made the top five species by weight. The scatter plot of landed catch versus estimated catch and a density histogram plot of landed catch/estimated catch shows that there are a large number of zeros in the plots indicating that many trips have returned a landed greenweight record, but no corresponding estimated catch in their corresponding effort records (Figure 6). Lastly, estimated catch is frequently, but not always, less than landed catch.

3.1.2 TRU 4

TRU 4 is the single most important QMA, accounting for over 59% of total reported landings over the 1989–90 to 2006–07 fishing years. The groomed and merged catch data are expressed by fishing year and various combinations of the variables month, reporting form type, method, target species, and statistical area in Figures 7–10. The sparse nature of this data set sometimes makes it difficult to distinguish between real trends/features in the data and 'noise'. However, clear patterns are described below.

There is little evidence for seasonality in the TRU 4 catch, although in recent years, when catches have been high, landings were greatest from spring through early autumn (Figures 7 and 8). Most of the catch was recorded from near the Chatham Islands (statistical areas 049–051) and over the Reserve Bank (statistical area 401, 407) which is on the Chatham Rise about 100 km east of the Mernoo Bank (Figures 7 and 9). The landings from statistical area 407 in 2006–07 were probably from the south end of the Reserve Bank. In the last few years, Chatham Island's statistical areas have provided the bulk of the trumpeter catch in TRU 4 (Figures 7 and 9).

Most of the TRU 4 trumpeter catch has consistently been caught by bottom longline, with lesser catches by dahn line and trot line in the mid 1990s (Figure 7 and 8). There were also modest catches by bottom trawl in recent years. Target species were mainly bluenose (BNS), hapuku (HAP), hakuku/bass (HPB), and ling (LIN), which are typically targeted using lining methods (Figures 7 and 9). Targeting for ling has declined over recent years, and since 2002–03 significant catches have been reported by vessels recording trumpeter as the target, using bottom longline.

The bulk of landings for bottom longlining and non trawling methods were from vessels completing CELR forms (Figure 10). Bottom trawling landings were mostly from larger vessels (over 28 m) using TCEPR forms indicating that much of the bottom trawl bycatch is from deeper water. Most of the vessels using bottom longline completed the longline specific LCER from 2003–04 onward, while the remainder of vessels using this method continued to report on CELRs (Figure 10). There have been no set net landings of trumpeter in TRU 4 since the introduction of the NCELR in 2006–07.

In general, methods used, areas in which caught, and total landings are strongly associated with the target species and may explain the large fluctuations in annual landings.

3.1.3 TRU 3

TRU 3 is the second most important QMA (after QMA 4), accounting for over 17% of total reported landings over the 1989–90 to 2006–07 fishing years. The groomed and merged catch data are expressed by fishing year and various combinations of the variables month, reporting form type, method, target species, and statistical area in Figures 11–14. These data are more sparse than those for TRU 4, making it difficult to distinguish between real trends/features in the data and 'noise'.

There is little evidence for seasonality in the TRU 3 landings, although very little has been landed in the winter months of July and August (Figures 11 and 12). Catches were recorded from all TRU 3 coastal statistical areas (018, 020, 022, 024, 026) and also offshore from Kaikoura (019) and over the Mernoo Bank (021) (Figures 11 and 13). The largest catches were from 018, 020, and 024, and more recently 021.

Most of the TRU 3 trumpeter catch has been taken by either set net or bottom longline, although catches by set net declined sharply after 1998 (Figures 11 and 12). There are also lesser catches by bottom trawl. Trumpeter is a bycatch of at least eight target species and more recently highest landings have been associated with targeting HPB and SCH (Figures 11 and 13). There are also modest landings with TRU recorded as the target.

The bulk of landings from bottom trawl were from vessels completing CELR forms with some reporting from larger vessels (over 28 m) using TCEPR forms in the early 1990s (Figure 14). Some vessels using bottom longline completed the LCER in 2004–05 and 2006–07, while the remainder of vessels using this method continued to report on CELRs (Figure 14). Similarly, after the introduction of the NCELR in 2006–07, it was used by all vessels landing trumpeter by set net in TRU 3.

Methods used, areas in which caught, and total landings are strongly associated with the target species and may explain the large fluctuations in annual landings.

3.2 Recreational fishery characterisation (TRU 3 and TRU 4)

The trumpeter length frequency distributions collected during recreational fishing surveys in TRU 3 and the adjacent Cook Strait and Wairarapa coast are shown in Figure 15. The TRU 3 distribution is strongly unimodal with a peak at 38 cm and a length range of 28 to 54 cm. The trumpeter from Cook Strait and Wairarapa were considerably larger, with the largest fish recorded at 96 cm. There is no information on the depths at which these fish were captured, but it is likely that the larger fish were from deeper offshore water.

The mean length of the TRU 3 fish recorded during recreational fishing surveys was 38.9 cm and by applying the length weight relationship (see Section 3.2.2) this corresponds to a mean weight of 952 g per fish. This mean weight was used to convert the numbers of fish estimated from recreational surveys to weights.

Recreational fishery harvest estimates are shown in Table 2. The MFish Plenary document states that the Recreational Technical Working Group considered that the 1996–97 survey (Bradford 1998) used a flawed survey methodology and underestimated recreational harvest (documented in other species such as blue cod, but not updated for trumpeter, Ministry of Fisheries 2009). The working group recommended using the results from the 1999–2000 national diary survey (Boyd & Reilly 2005), and those from the 1997–98 charter boat diary survey (James & Unwin 2000). Accordingly, recreational harvest estimates from these latter two surveys for TRU 3 were 41 000 and 1500 fish respectively, and this converted to weights of 39.0 t and 1.4 t (Table 2). Hence, trumpeter is an important recreational species and the harvest estimates in 1999–2000 for TRU 3 are about four times greater than the average commercial catch over the last 10 years (10.6 t up to 2007–08). The recreational harvest in TRU 5 is also substantially greater than the commercial catch.

There are no recreational fishing survey data for TRU 4.

3.3 Trumpeter sampling to estimate length at maturity

3.3.1 Samples

Of the five commercial operators and the recreational/charter boat fishers, only the Kaikoura and Stewart Island commercial set netters provided samples in 2008 (Table 3). No additional samples were forthcoming in 2009 despite an extension to the programme in an attempt to increase sample numbers.

We aimed to collect 200 samples, but obtained only 81 fish. The fish were caught mainly by commercial set nets from three locations during August–November 2008: 64% of the fish were caught from South Cape of Stewart Island, and the rest from north of Kaikoura (21%) and Karitane, North Otago (15%) (Table 3). The Karitane sample, provided by the Ministry of Fisheries Dunedin Compliance, was of undersized fish confiscated from a recreational fisher. No samples were otherwise voluntarily provided by recreational fishers or charter boat operators.

3.3.2 Length and weight data

The recorded fork length ranged between 23 and 74 cm for the 81 sampled trumpeter (Figure 16). Of 81 fish, there were 40 females, 39 males, and 2 of unknown sex. The sex ratio is therefore close to 1:1. The overall mean fish length was 42.0 cm and the median was 38.0 cm. There was little difference between male and female distributions and mean lengths were similar (42.2 cm and 41.8 cm respectively).

There were three distinct size classes reflecting the capture locations (Figure 16). Fish caught from shallow inshore water (Stewart Island and Karitane) fell into the two small classes, whereas the large size class comprised fish caught offshore in deeper water near Kaikoura. Overall the median and mean of Karitane fish were 25.5 and 24.7 cm, respectively, and for Stewart Island 37.0 and 37.1 cm, respectively. In contrast, for Kaikoura fish the median and mean were 67.0 and 64.8 cm respectively, more than twice those of Karitane fish.

The trumpeter length-weight relationship (both sexes combined) is expressed in the model form $W = aL^b$, where W = weight (g), and L = length (cm). a = 0.011612, b = 3.09 (n = 81; range 23–74 cm, 242– 7152 g; $R^2 = 0.99$).

3.3.3 Gonad maturity

Examples of the observed gonad stages for males and females are shown in Figures 17 and 18. Stages 5 and 7 gonads (running ripe or spent) were not observed.

Gonadsomatic index (GSI) is expressed as percentage of gonad weight to fish body weight and reflects spawning status (Figure 19). For stage 1 fish, GSI ranged from 0.01 to 0.25, and stage 2 GSI was similar (0.04 to 0.31). For stages 3 to 6 fish (60 cm and over), GSI ranged from 1.2 to 5.1 (excluding partially spent fish), and for the same length, females generally had a larger GSI than males (Figure 19). The low GSI values for stage 2 gonads suggest that these are very unlikely to be mature fish, so we defined both stages 1 and 2 as immature (non-spawning).

There is a clear distinction of gonad weight between immature/resting fish (stages 1 and 2) and stages 3 to 6 (Figure 20). For gonad stages 1 and 2, the gonad weight was less than 2 g, but for mature fish (gonad stages 3–6), gonad weights were all above 110 g. There was no significant difference in gonad weight among stages 3 to 6 (ANOVA, $p > 0.53$).

The smallest mature (stages 3 to 6) length was 60 cm (Figure 21). All Kaikoura fish were mature, whereas all those from Karitane and Stewart Island were immature (gonad stages 1 and 2). Because there were no sizes with both immature and mature fish, it was not possible to fit a logistic curve to the maturity data or to estimate length at 50% maturity, but it is clear that they mature somewhere between 45 and 60 cm.

3.4 Fisheries observer data

The frequency data collected by Ministry of Fisheries observers came from throughout New Zealand, but most were from the lower east coast North Island, Mernoo Bank, Chatham Islands, and south of Stewart Island (Figure 22). Lengths ranged from 41 to 86 cm (median length = 67 cm), but most fish were between about 55 and 74 cm fork length with about equal number of males and females. Most of these fish would have been caught in deeper offshore water. The size distribution is similar to that of the Kaikoura fish sampled in this study, but larger than that of inshore trumpeter sampled from Stewart Island and Karitane.

4. DISCUSSION

4.1 Characterisation of the TRU 3 and TRU 4 fishery

The characterisation of the commercial fishery in TRU 3 and TRU 4 showed that trumpeter landings are small, variable, and possibly cyclical. Further, there is little seasonal component to catches which tend to be a bycatch mainly of bottom longlining, bottom trawling, and set netting directed at species such as hapuku, bluenose, and ling. The variability in landings may be more related to the characteristics of other fisheries than to inherent changes in trumpeter biomass.

The estimate of trumpeter recreational catch in TRU 3 in 1999–2000 was 39 t (see Table 2), nearly four times greater than the commercial catch in TRU 3 in that year. While we have no recreational catch estimates for other years, it is likely that the recreational catch was greater than the TRU 3 commercial catch, which averaged 10.6 t over the last 10 years. There are no recreational catch estimates for TRU 4 and this is probably a reflection of the lack of fishing effort in this area.

4.2 Size at maturity and maximum age

An objective of this study was to estimate the length at maturity of trumpeter. A logistic model fitted to the proportion mature by length is commonly used to estimate size at 50% maturity. This information could then be used to assess the MLS, which is currently 35 cm. Although we sampled 81 trumpeter, they were either small and immature or large and mature, and this was clearly a function of the location in which the fish were caught (see Figure 16). The immature fish (under 45 cm) came from inshore Stewart Island while targeting butterfish in shallow water, and from inshore Karitane (line caught). All the large mature fish (over 60 cm) were from Kaikoura and were landed as bycatch of targeting species such as rig, school shark, and hapuku. Attempts to acquire samples in the intermediate size range (45–60 cm) were unsuccessful, and hence fitting a logistic model to the proportion mature at length was pointless.

Maturation of Australian trumpeter was assumed to occur at about 45 cm, which coincides with the size that they migrate offshore (Tracey & Lyle 2005). Our results tend to support the view that New Zealand trumpeter mature when they migrate from inshore habitats to deeper water. No fish over 45 cm was found inshore in our sampling, but this may have been partly biased by the limited number of both samples and locations of these samples. The recreational length frequency data support the division of trumpeter life history into inshore and offshore phases based on size and maturity (see Figure 15) — the fish caught by recreational fishers from TRU 3 were similar in size to those in our inshore samples, but the large fish were caught almost exclusively in Cook Strait and off the Wairarapa coast, areas which have deep water near the coast. The largest fish caught by Chadderton & Davidson (2003) in Paterson Inlet was 46 cm, providing further evidence that trumpeter migrate offshore to spawn. Further, the observer length frequency data comprise virtually all large fish (over 55 cm), reflecting the observer coverage of vessels in the deepwater trawl and longline fisheries (see Figure 22).

We have no reason to suspect that New Zealand trumpeter behave differently from their conspecifics in Australia and the evidence above indicates that migration offshore and maturation are closely linked. We estimate that 50% maturity occurs between 45 and 50 cm. Fish between 35 cm (the MLS) and at least 45 cm are probably immature and have not spawned. The recreational fishery is therefore largely based on immature fish (see Figure 15).

Future trumpeter sampling should focus on fish of intermediate sizes (45 to 60 cm) in order to estimate precisely the length at maturity. To obtain an estimate of maximum age, trumpeter over about 100 cm FL will be required. The maximum known length is 120 cm, but the largest fish we have records for is 96 cm (see Figure 15), so fish around this size will provide an indication of the maximum age of fish in the fishery today. The most likely potential source of large fish for estimating maximum age, and also of fish in the 45–60 cm range for estimating size at 50% maturity, is the MFish Observer Programme.

5. ACKNOWLEDGMENTS

This research was carried out by NIWA under contract to the Ministry of Fisheries (Project TRU200701). We are grateful to Dick Cleall, Campbell McManus, and MFish compliance (Dunedin) for providing the trumpeter samples. Thanks to NIWA staff Derek Kater for sampling assistance, Mike Beardsell for editorial comments, and to Stephen Brouwer (MFish) for reviewing the manuscript.

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Table 1: Gonad staging descriptions used for maturity study of trumpeter (NIWA middle-depth staging method).

		Males	Females
1	Immature	Testes small and translucent, threadlike or narrow membranes	Ovaries small and translucent No developing oocytes
2	Resting	Testes thin and flabby; white or transparent.	Ovaries are developed, but no developing eggs are visible.
3	Ripening	Testes firm and well developed, but no milt is present	Ovaries contain visible developing eggs, but no hyaline eggs present.
4	Ripe	Testes large, well developed; milt is present and flows when testis is cut, but not when body is squeezed.	Some or all eggs are hyaline, but eggs are not extruded when body is squeezed.
5	Running-ripe	Testis is large, well formed; milt flows easily under pressure on the body.	Eggs flow freely from the ovary when it is cut or the body is pressed.
6	Partially spent	Testis somewhat flabby and may be slightly bloodshot, but milt still flows freely under pressure on the body.	Ovary partially deflated, often bloodshot. Some hyaline and ovulated eggs present and flowing from a cut ovary or when the body is squeezed.
7	Spent	Testis is flabby and bloodshot. No milt in most of testis, but there may be some remaining near the lumen. Milt not easily expressed even when present.	Ovary bloodshot; ovary wall may appear thick and white. Some residual ovulated eggs may still remain but will not flow when body is squeezed.

Table 2: Recreational harvest estimates (numbers) from the three national recreational fishery harvest surveys. Weights were estimated in this study from mean weight.

		TRU 3		TRU 5		
Survey	Type	Number	Weight (t)	Number	Weight (t)	Reference
National diary survey 1996–97	Recreational fishers	13 000	12.4	21 000	20.0	Bradford 1998
National diary survey (1997–98)	Charter boat operators	1 500	1.4	7 700	7.3	James & Unwin 2000
National diary survey 1999–2000	Recreational fishers	41 000	39.0	23 000	21.9	Boyd & Reilly 2005

Table 3: Sources of trumpeter samples collected for age and growth study. * averaged from the Kaikoura October landings because no depth provided. ** assumed from location because no depth provided.

Landing_no	Date landed	No. fish	Location fish caught	Depth	Method
20088201	11-Aug-08	33	South Cape of Stewart Island	2–5 m	set net (4 1/4")
20088202	25-Sep-08	19	South Cape of Stewart Island	2–5 m	set net (4 1/4")
20088203	29-Oct-08	1	North of Kaikoura	110 m	set net (7")
20088204	28-Oct-08	4	North of Kaikoura	115 m	set net (7")
20088205	31-Oct-08	9	North of Kaikoura	103 m	set net (7")
20088206	2-Nov-08	3	North of Kaikoura	*109 m	set net (7")
20088207	15-Nov-08	12	Karitane (North Otago)	**< 10 m	line caught

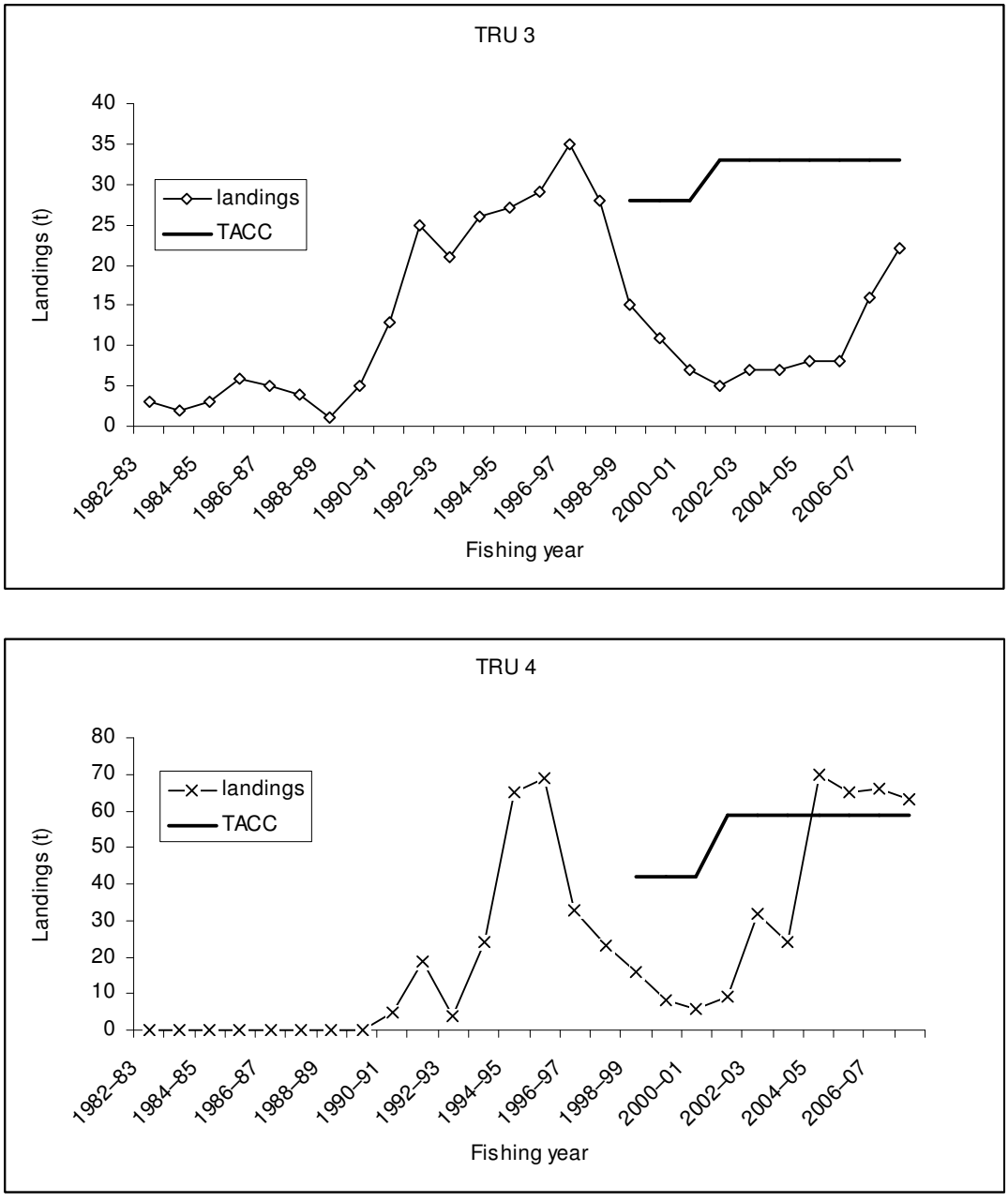


Figure 1: Reported landings and TACCs of trumpeter for TRU 3 and TRU 4 for the fishing years 1982–83 to 2007–08 (Ministry of Fisheries 2009, from table 2).

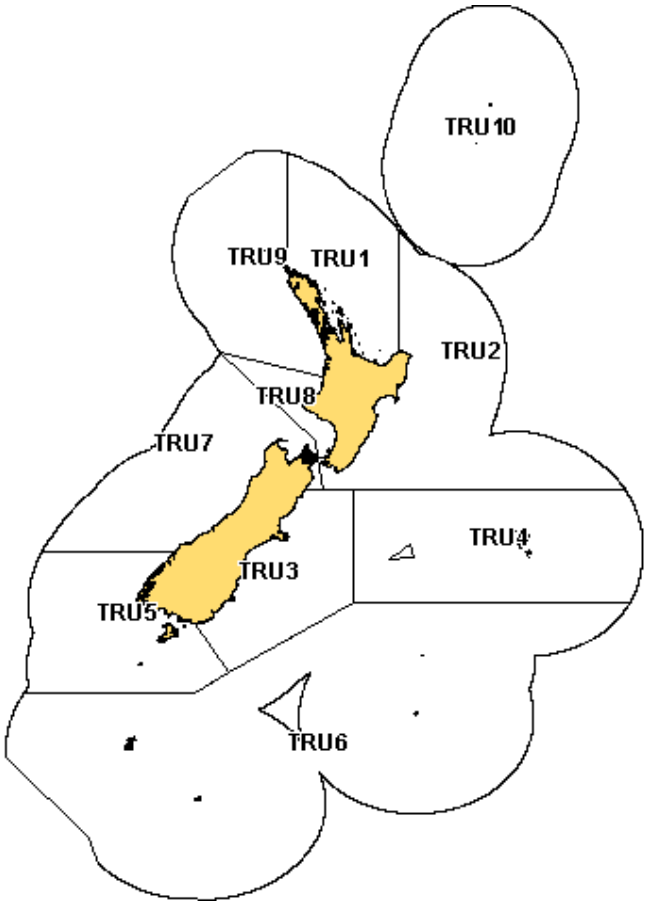


Figure 2: Trumpeter QMAs (from Ministry of Fisheries, 2009).

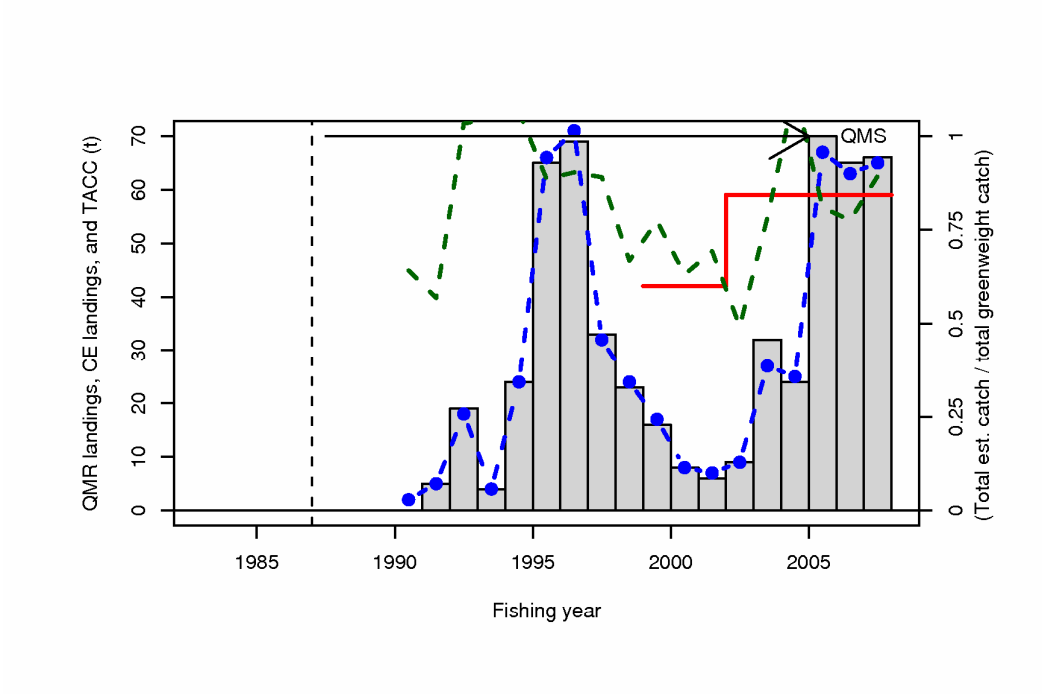


Figure 3: The relationship between landed and estimated catch in TRU 4. Illustrated are the QMR catch (grey histogram, Monthly Harvest Returns), the landed greenweight catch from the Catch Landing Returns (broken line with dots,), and the total estimated catch as a proportion of the total landed greenweight catch per fishing year (broken line). The TACC is also shown (solid line).

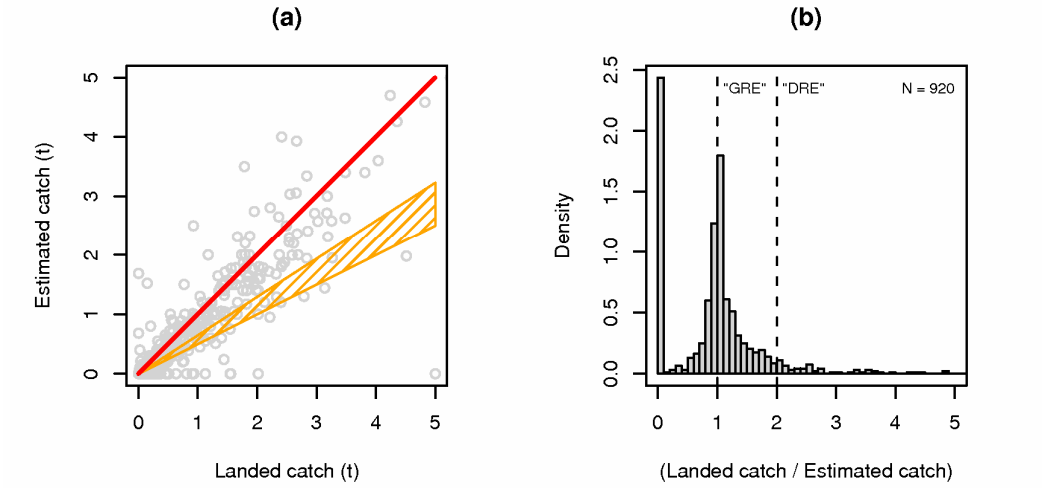


Figure 4: The total estimated trumpeter catch per fishing trip for TRU 4 is plotted against the total landed trumpeter catch per fishing trip on the left; the solid line indicates a one to one relationship, and the hatched distribution represents the catch incorrectly reported as dressed. Landed catch as a proportion of estimated catch is plotted as a histogram on the right. Note the large number of zeros showing that many vessels have returned a landed greenweight record but no corresponding estimated catch. GRE , greenweight state; DRE, dressed state.

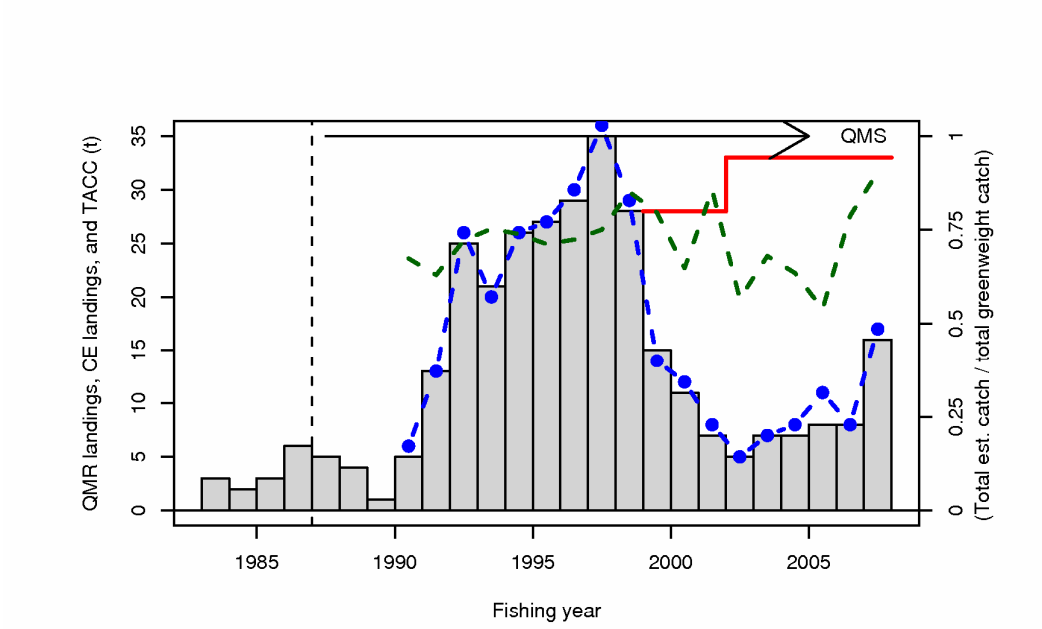


Figure 5: The relationship between landed and estimated catch in TRU 3. Illustrated are the QMR catch (grey histogram, Monthly Harvest Returns), the landed greenweight catch from the Catch Landing Returns (broken line with dots), and the total estimated catch as a proportion of the total landed greenweight catch per fishing year (broken line). The TACC is also shown (solid line).

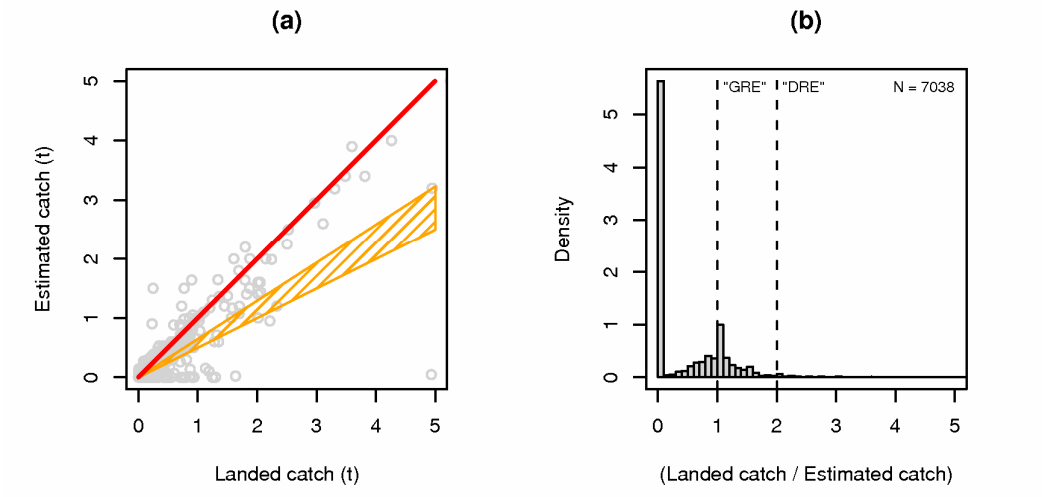


Figure 6: The total estimated trumpeter catch per fishing trip for TRU 3 is plotted against the total landed trumpeter catch per fishing trip (left) the solid line indicates a one to one relationship, and the hatched distribution represents the catch incorrectly reported as dressed. Landed catch as a proportion of estimated catch is plotted as a histogram (right)–the large number of zeros indicates that many vessels returned a landed greenweight record but no corresponding estimated catch in their corresponding effort records. GRE , greenweight state; DRE, dressed state.

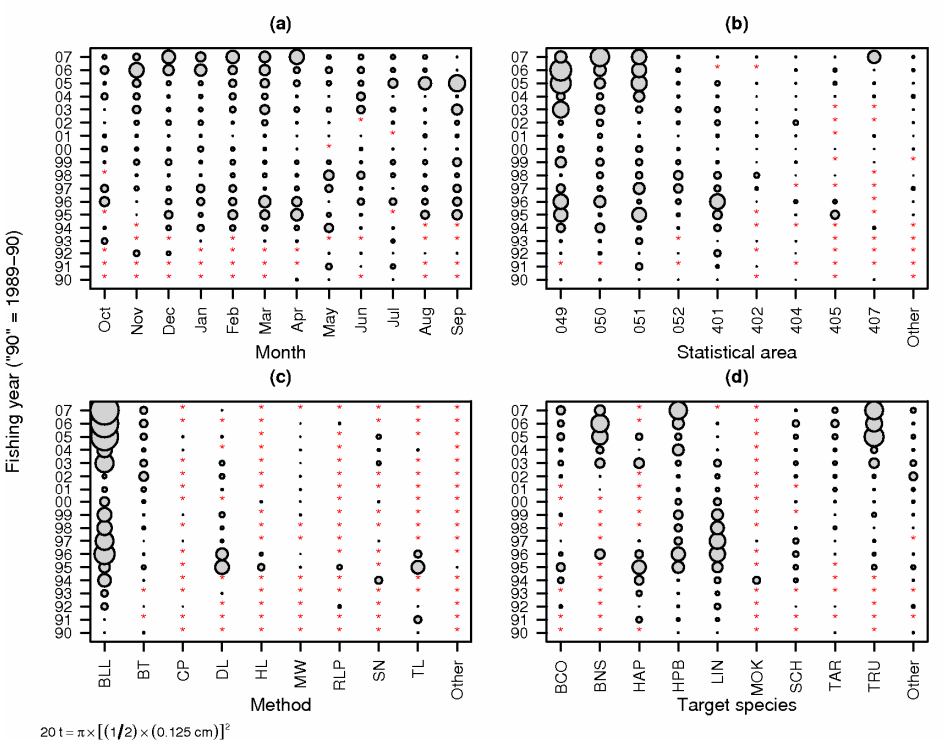


Figure 7: Groomed catches in TRU 4 (a) by month and fishing year, (b) by statistical area and fishing year, (c) by method and fishing year and (d) by target species and fishing year. Circle areas are proportional to the amount of catch in each factor level and fishing year combination and are equivalent among plots. BLL, bottom longline; BT, bottom trawl; CP, cod pot; DL, dahn line; HL, hand lining; MW, mid water trawl; RLP, rock lobster pot; SN, set net; TL, trot line.

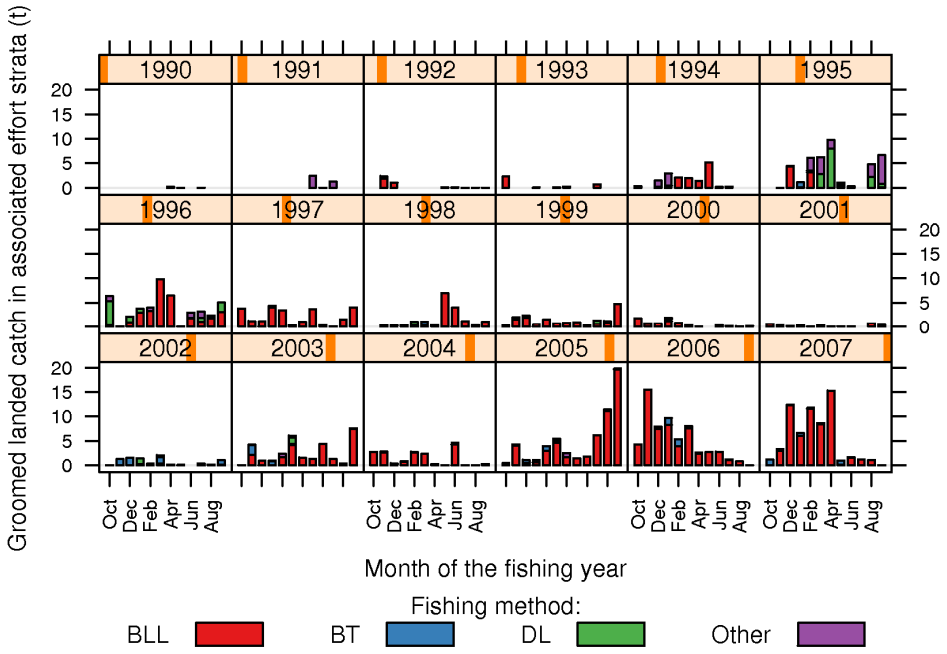


Figure 8: Groomed catches in TRU 4 by fishing year, month, and fishing method for the fishing years 1990–2007.

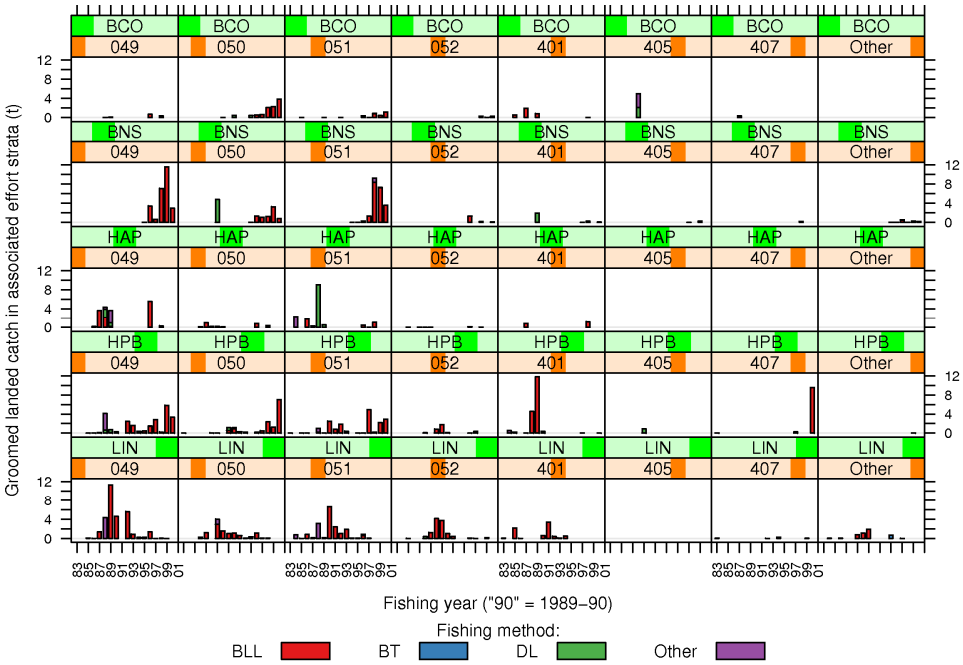


Figure 9: Groomed catches in TRU 4 by fishing year, target species, statistical area, and fishing method for the fishing years 1990–2007.

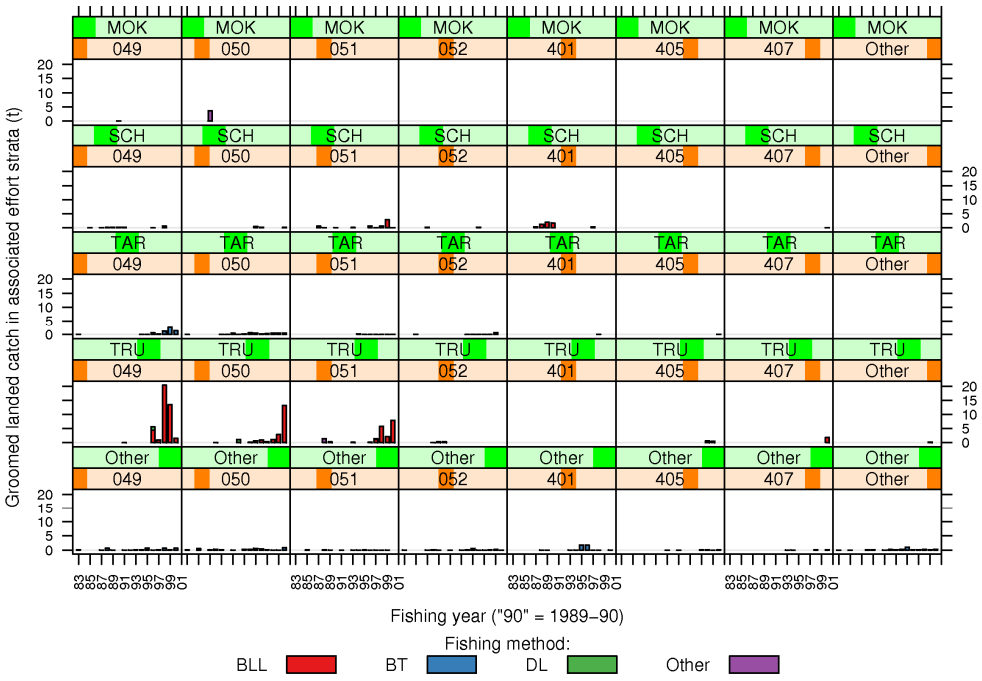


Figure 9 – *continued*.

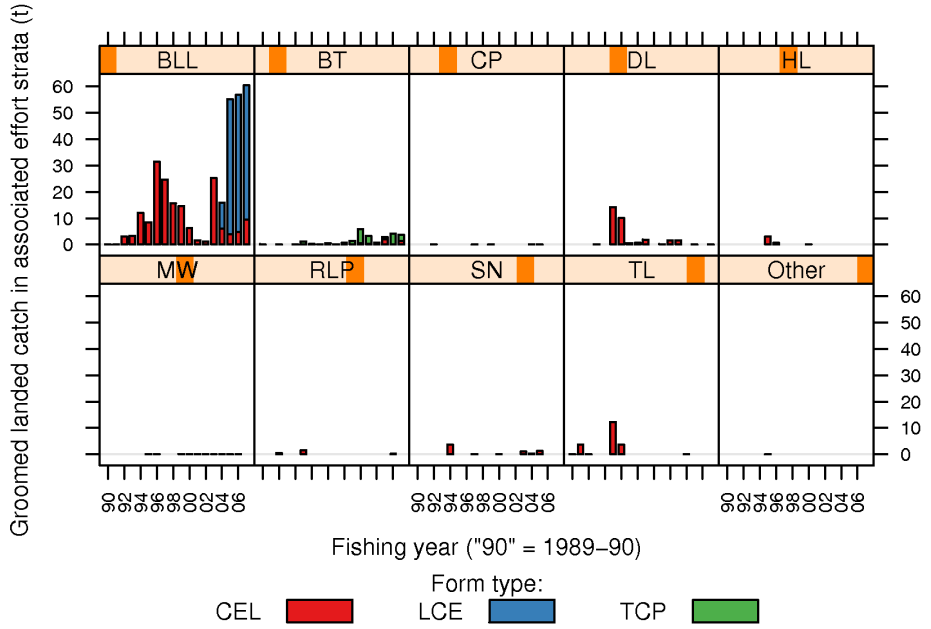


Figure 10: Groomed catches in TRU 4 by fishing year, fishing method, and catch-effort record form type, and for the fishing years 1990–2007.

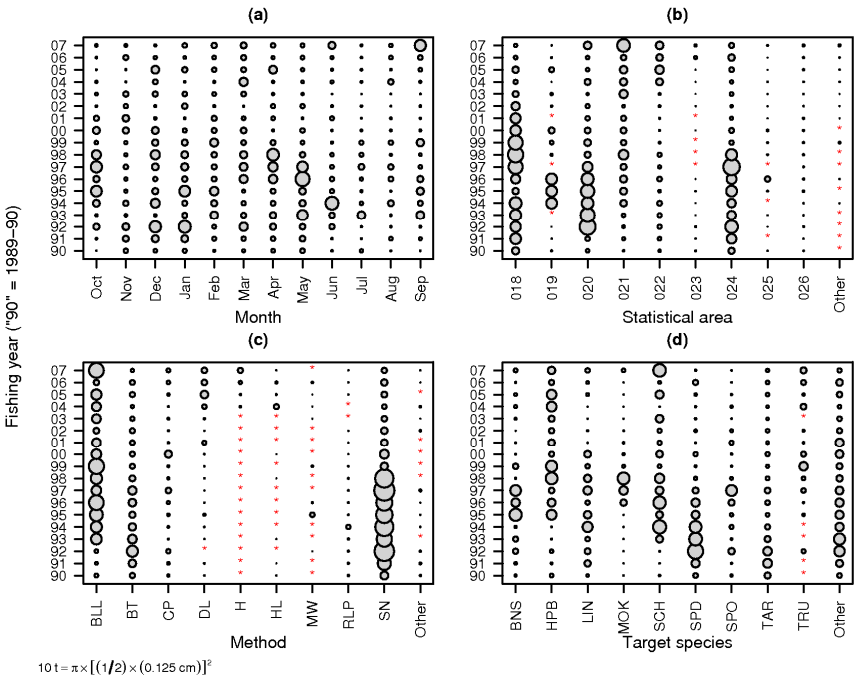


Figure 11: Groomed catches in TRU 3 (a) by month and fishing year, (b) by statistical area and fishing year, (c) by method and fishing year, and (d) by target species and fishing year. Circle areas are proportional to the amount of catch in each factor level and fishing year combination and are equivalent among plots. BLL, bottom longline; BT, bottom trawl; CP, cod pot; DL, dahn line; HL, hand lining; MW, mid water trawl; RLP, rock lobster pot; SN, set net; TL, trot line.

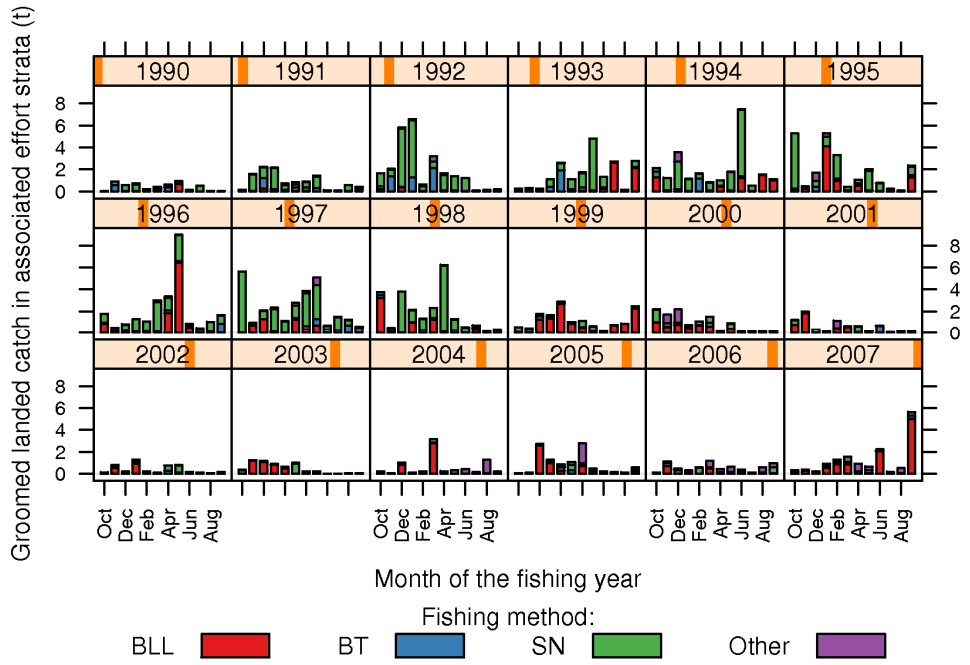


Figure 12: Groomed catches in TRU 3 by fishing year, month, and fishing method for the fishing years 1990–2007.

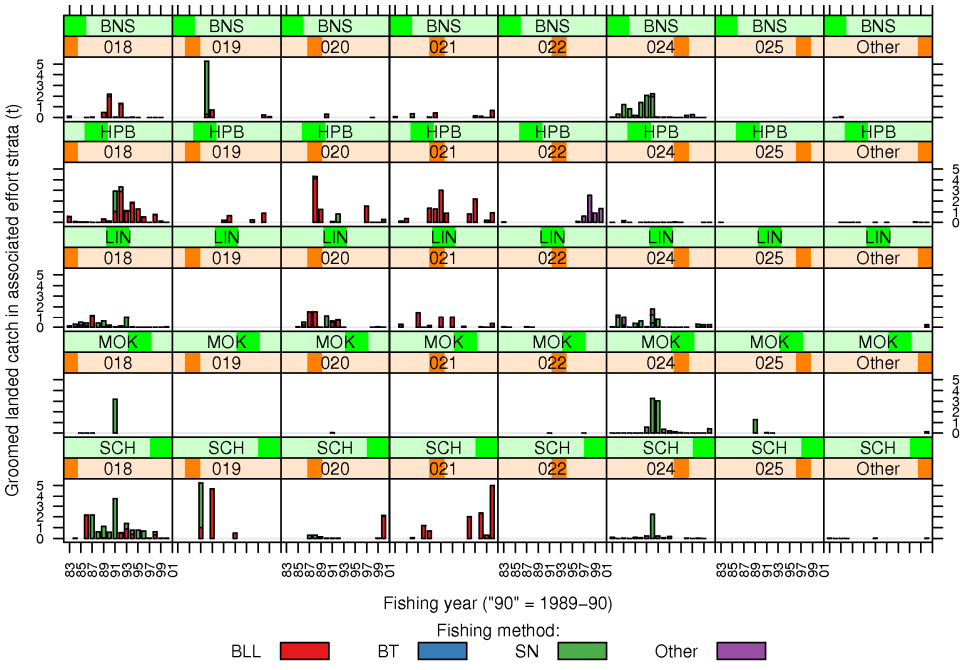


Figure 13: Groomed catches in TRU 3 by fishing year, target, statistical area, and fishing method for the fishing years 1990–2007.

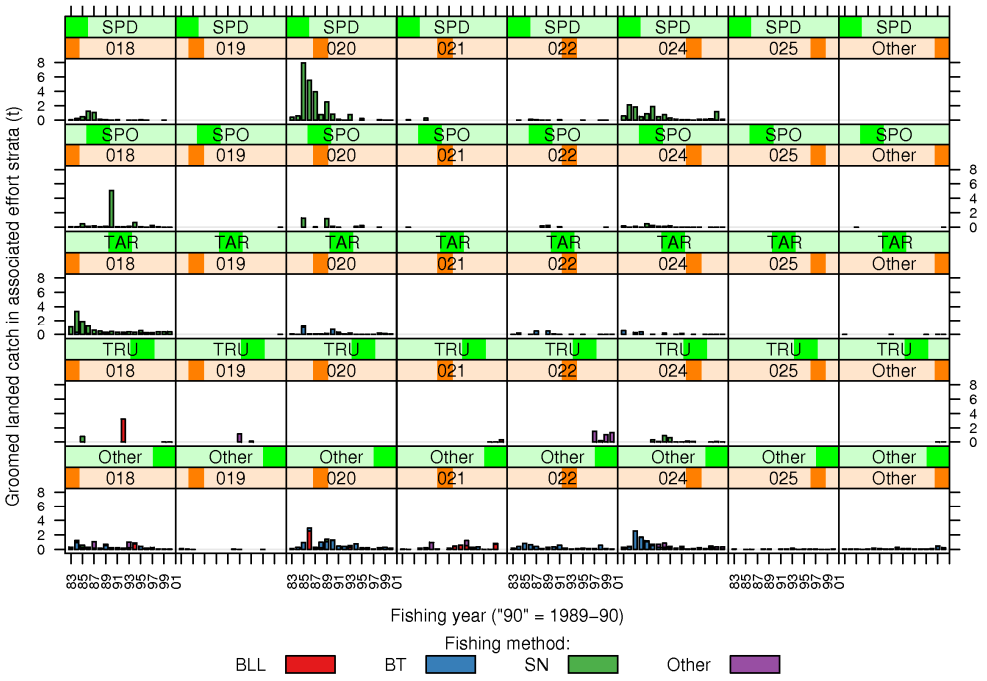


Figure 13 – ***continued***

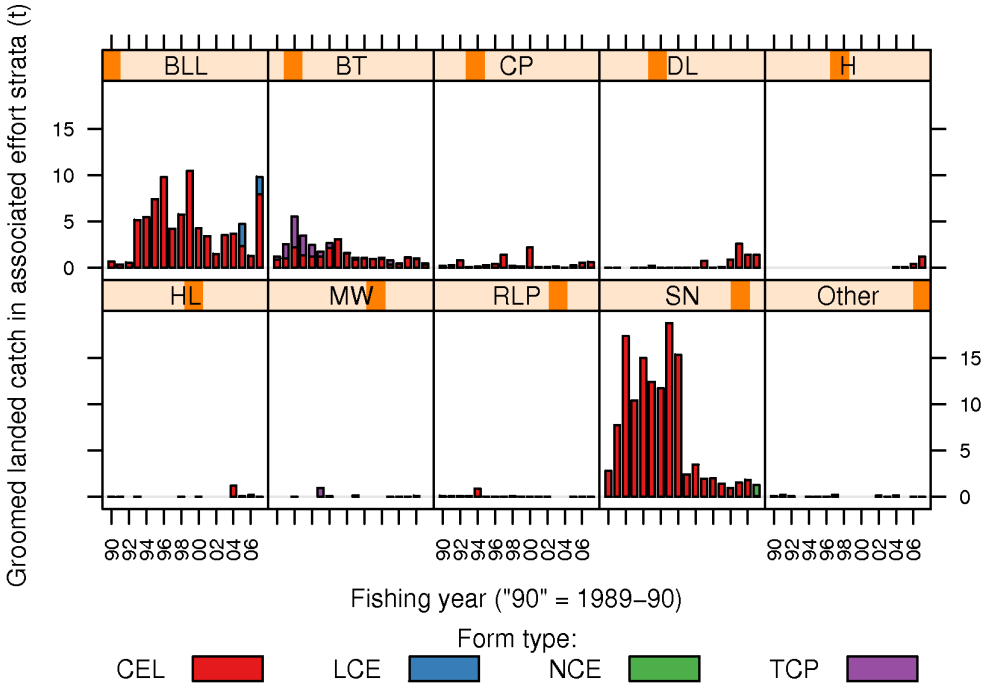


Figure 14: Groomed catches in TRU 3 by fishing year, fishing method and catch-effort record form type, and for the fishing years 1990–2007.

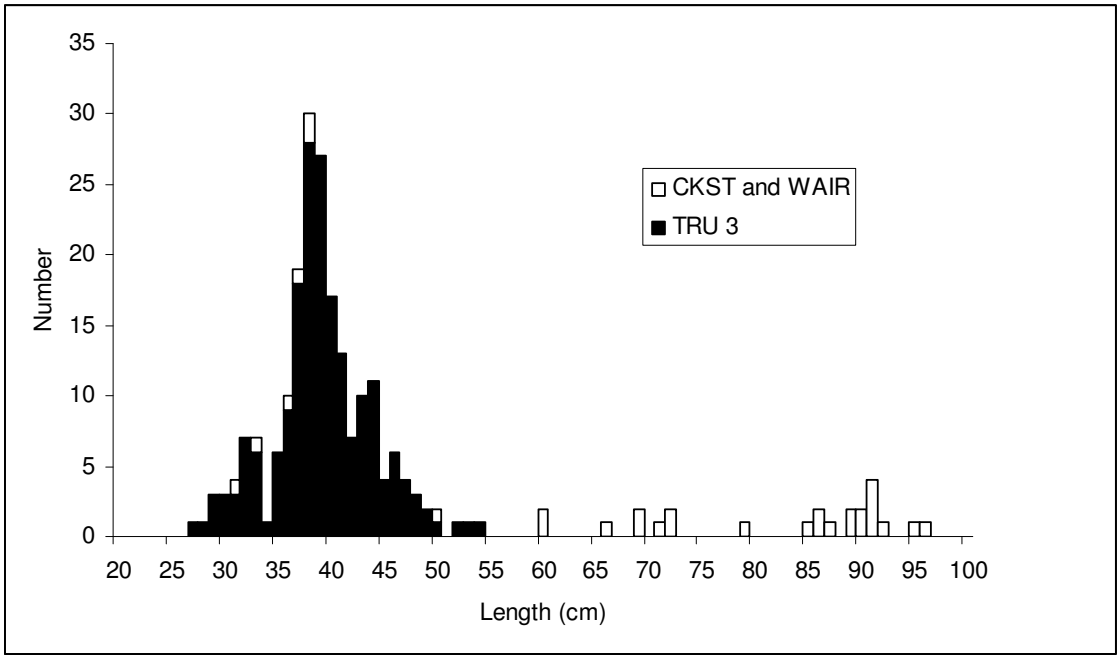


Figure 15: Trumpeter length frequency distribution from rec_data database for fish_zones within TRU 3 and also those from Cook Strait (CKST) and the Wairarapa coast (WAIR). These data are from recreational surveys in 1996–97 (survey NAT96) and 1999–2000 (survey NAT00). *n* = 194 (TRU 3) and *n* = 31 (CKST and WAIR), all fish unsexed. Length measurement method unknown but assumed to be fork length.

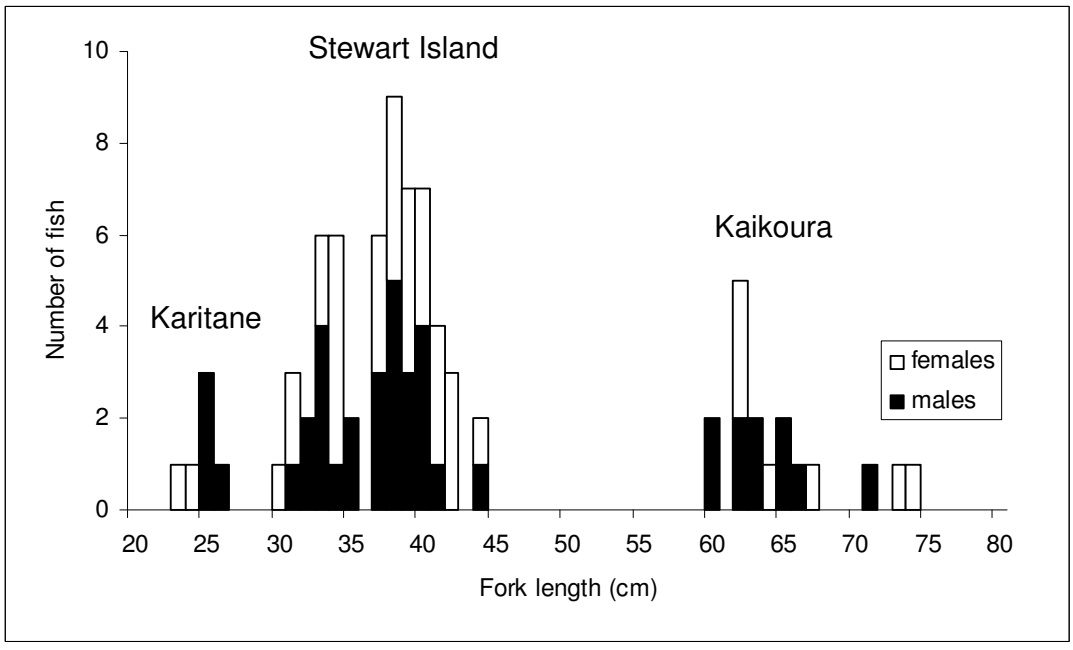


Figure 16: Length frequency distribution of trumpeter sampled during this study. The area of capture is noted above the lengths (see Table 3 for details). *n* = 41 males and 40 females.

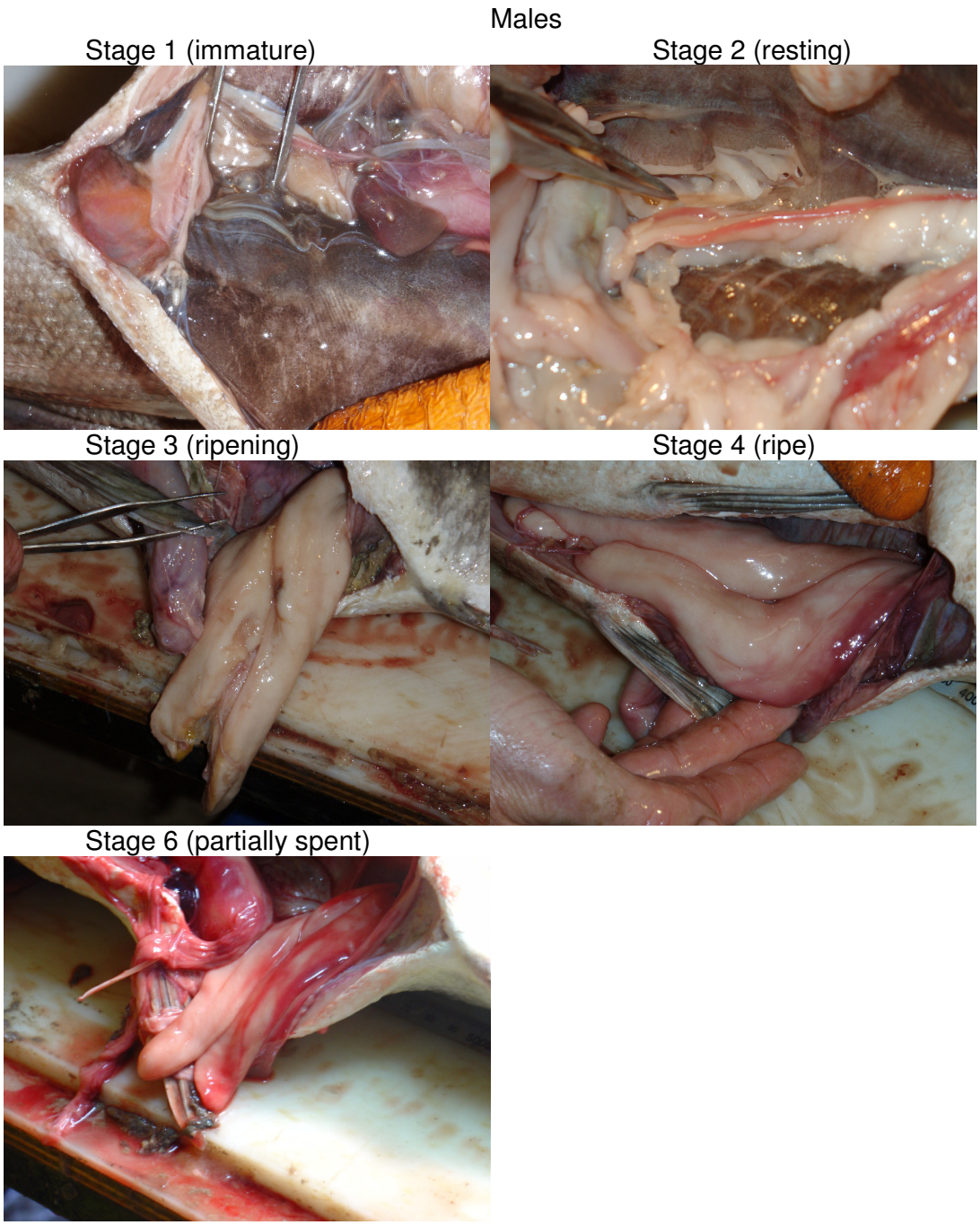
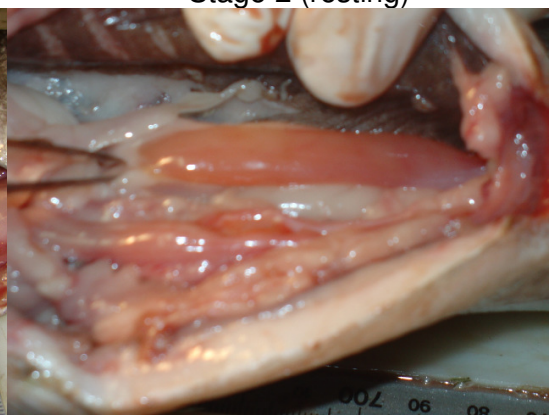


Figure 17: Observed gonad stages of male trumpeter.

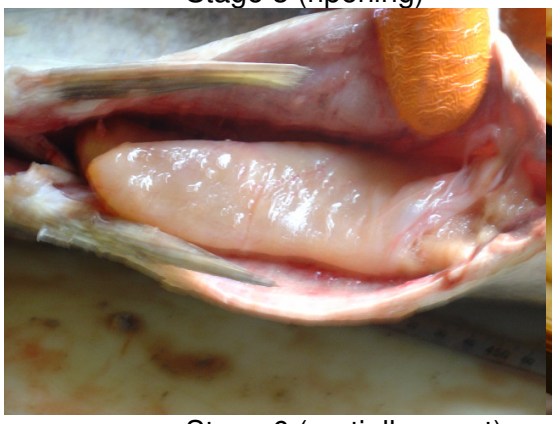
FEMALES

Stage 1 (immature)

Stage 2 (resting)



Stage 3 (ripening)



Stage 4 (ripe)

Stage 6 (partially spent)

Figure 18: Observed gonad stages of female trumpeter.

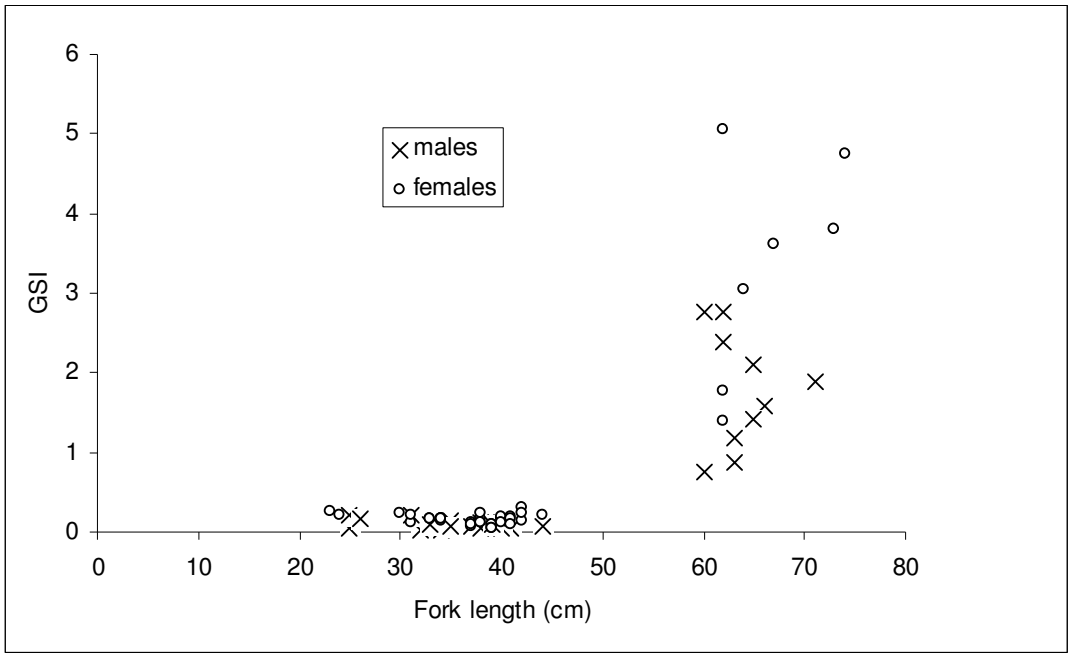


Figure 19: Relationship between gonadosomatic index (GSI) and fork length for sampled trumpeter. *n* = 39 males and 40 females.

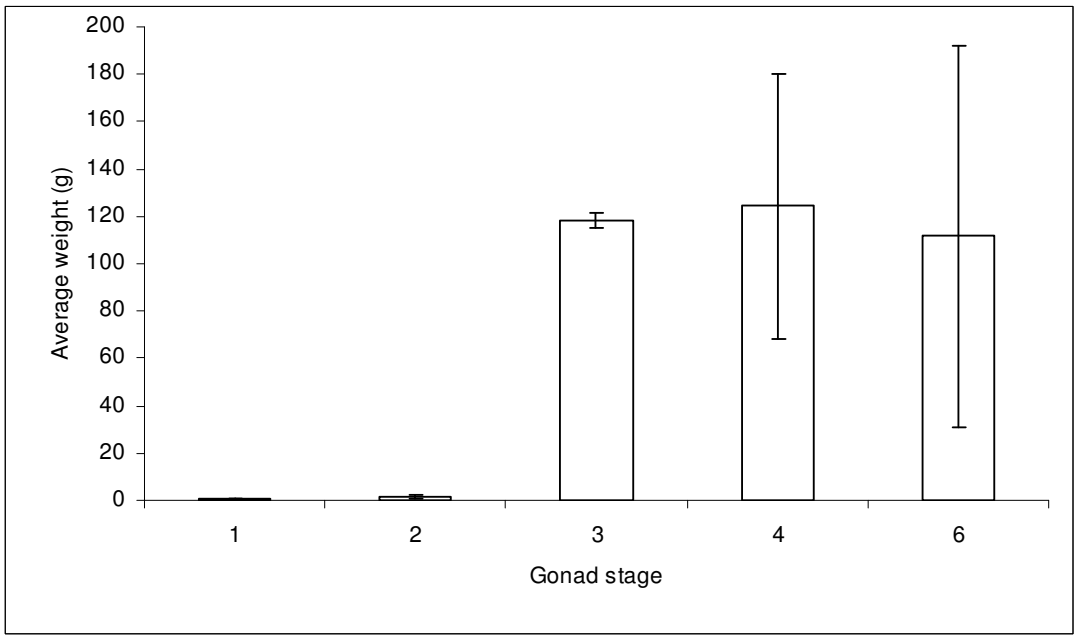


Figure 20: Average gonad weight for each gonad stage (both sexes combined). *n* = 79.

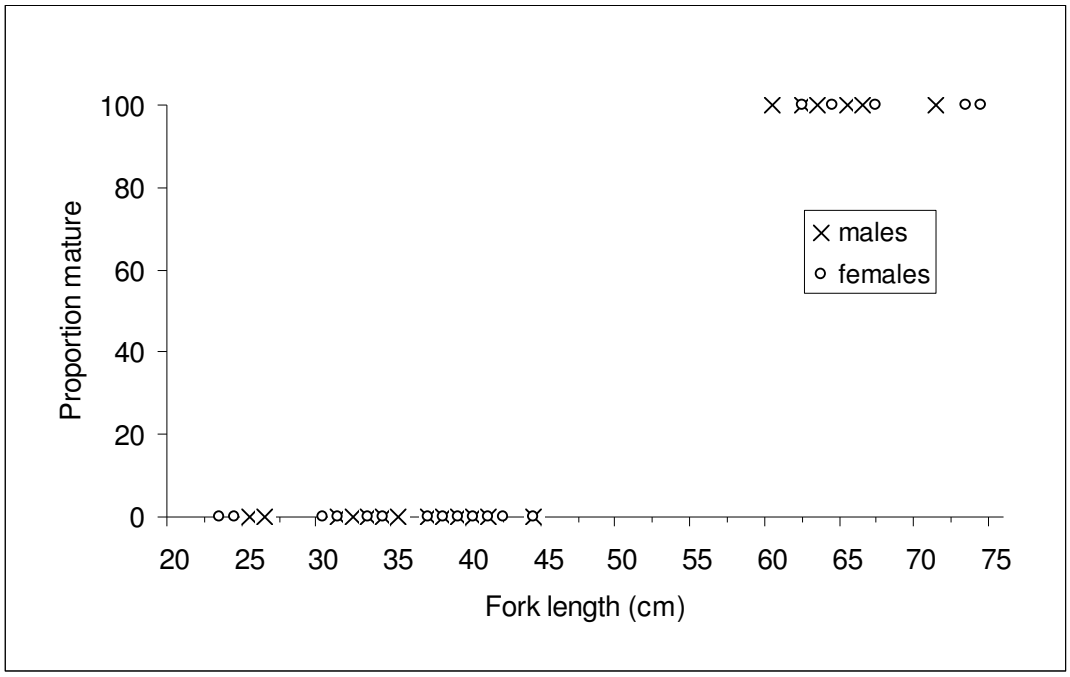


Figure 21: Proportion at length that were mature (gonad stages 3–7) for sampled trumpeter. *n* = 39 males and 40 females.

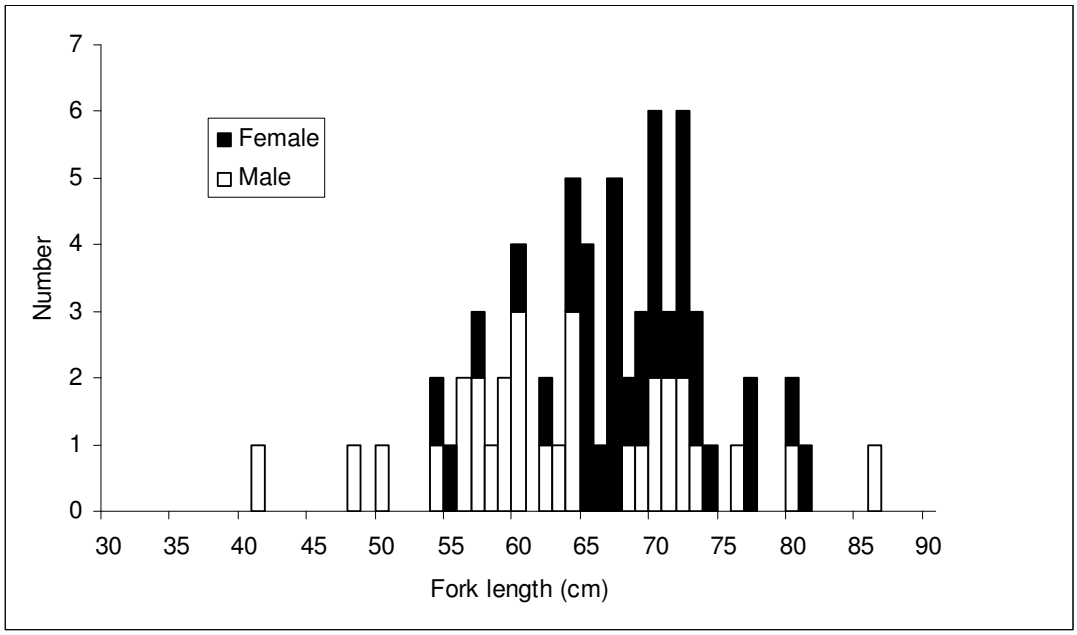


Figure 22: Trumpeter length frequency distribution from observer database. These data include all records of trumpeter length and were from throughout New Zealand for the period 1998 to 2008. *n* = 31 males and 36 females.